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NASA TECH BRIEF

New Method for Critical Failure Prediction of Complex Systems

A rigorous analytical technique, called "criticality determination methodology" (or CD technique) has been developed for determining the probability that a given complex system will successfully achieve stated objectives. The CD technique identifies critical elements of the system (e.g., a Saturn V Launch Vehicle/Apollo mission) by a failure mode and effects analysis. A critical element is defined as one whose failure (critical failure) may result in one or more objective losses.

As an illustration, in order to determine the contribution of the Saturn V Launch Vehicle to the possible loss of the Apollo Mission, a numerical prediction quantity (criticality number) is generated by criticality analysis techniques. Each stage, system, subsystem, and component is analyzed to determine its contribution to the loss of mission, vehicle, crew, or other critical objective. Critical components are identified, and a criticality number is calculated for each component. The component criticality numbers are then combined in determining subsystem, system, stage, and vehicle criticality numbers. The criticality number is defined as the expected number of objective losses (vehicle, mission, or crew) in a million preflight or flight attempts (as applicable) attributable to failure of a given component in a specific mode and environmental condition during a given period of operation. Criticality numbers can be assigned to components, subsystems, stages, vehicles, missions, and crews for any given failure distribution.

The CD technique has been employed successfully in making reliability determinations of the Saturn V vehicle by analyzing all the critical components in their critical modes for single failure points of all the stages and systems for prelaunch and flight operations. A single failure point (critical) is defined as a single component whose failure by itself may result in an objective loss.

By means of the CD technique the probability of an objective loss is determined by multiplying the probability of a specific failure, the failure mode proportion, and the probability of an objective loss should the given failure occur.

The CD technique has been completely automated for the Saturn V Launch Vehicle/Apollo mission. Raw data is fed directly into the computer, which automatically performs all data reduction and calculations and produces final report printouts. The technique integrates the results of many separate analyses which were not combined or even compatible in previous techniques. Some examples of such separate analyses pertain to failure mode and effects, criticality, reliability, safety, flight trajectory, systems operations research, and time line.

Notes:

1. The CD technique should be particularly applicable to urban planning, air and water pollution problems, and to oceanology.
2. Complete details may be obtained from:

   Technology Utilization Officer
   Marshall Space Flight Center
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Patent status:

No patent action is contemplated by NASA.

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